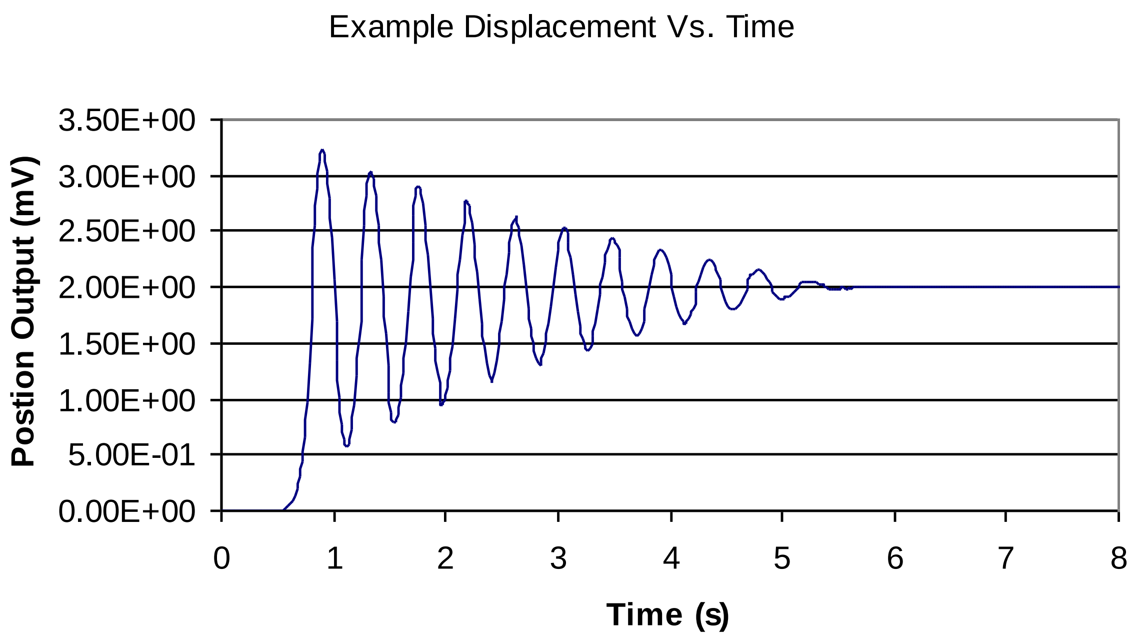
Notes on Data Reduction for Lab 2a

The notes below are intended to supplement, not replace the lecture material on system response. The objective of this write-up is to point out the key points from lecture material related to analysis and are not intended to replace the lecture material.

Workstation 1: Mass, Spring, and Damping

During this experiment you will measure the three masses (m) the spring constant (k). You will also record the position and acceleration data versus time for the system for each of the masses. See an example of the position data below.



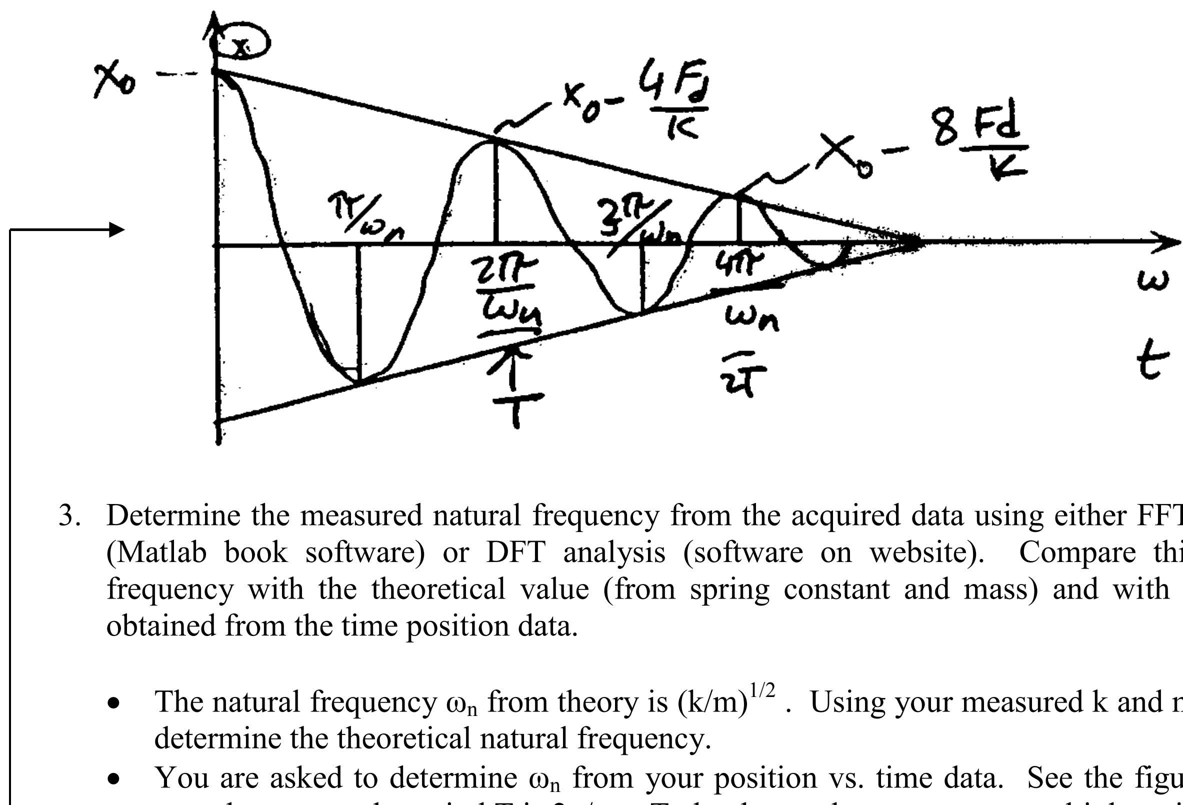
A summary of the tasks you should perform in the analysis of the experimental results follows:

1. Discuss your observations of the measurements, including displacement and acceleration. Make an example plot the acceleration and position data so they can be directly compared.

    - Do the plots make physical sense? Just discuss, no analysis is required.

2. Based on an appropriate physical model, discuss the "apparent" damping of the system, e.g., Coulomb versus viscous damping. See pages 53-58 of the lecture notes by Prof. Chen on the course website for the theoretical development of this dynamic system. Assuming that the system is Coulomb damping, determine the frictional force for each loading.

    - The plot below is taken from the website notes by Prof. L.D. Chen (pg. 58). A second order system with a constant “frictional” damping shows the amplitude decaying linearly**; at each cycle the amplitude decrement is 4 F_d/k where F_d is the frictional force.** It would be best to use several measurements at each mass to estimate F_d. It is interesting to see if F_d is constant for all masses; if not, does it increase or decrease with the mass, velocity, etc.? Discuss this in your write-up and logbook.



3. Determine the measured natural frequency from the acquired data using either FFT analysis (Matlab book software) or DFT analysis (software on website). Compare this natural frequency with the theoretical value (from spring constant and mass) and with the value obtained from the time position data.

   - The natural frequency ω_n from theory is $(k/m)^{1/2}$. Using your measured k and m you can determine the theoretical natural frequency.
   - You are asked to determine ω_n from your position vs. time data. See the figure above, note that one cycle period T is $2\pi/\omega_n$. To be thorough, you can use multiple estimates. Is the value constant?
   - Finally, you can analyze your position vs. time data using FFT or DFT analysis to determine a natural frequency to compare with the two discussed above. Note that you will have to do this for the three masses, and discuss the effect of mass on ω_n.

4. Discuss uncertainty of measurements. Note: uncertainty analysis may or may not be requested for this workstation. Instructor will announce.

   - All measurements of k, m, ω_n and F_d must have some estimate of uncertainty. You will be graded on whether you perform these uncertainty calculations correctly and how thorough you perform them.
   - In order to discuss the uncertainty results, you must perform them.

5. Final thoughts: Other than recording and presenting the accelerometer plots, we do not make use of the accelerometer measurements. However, you might remark on anything in its signal (i.e. spikes and noise).